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Joule-Thief Circuit Performance for Electricity Energy Saving of Emergency Lamps

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Joule-Thief Circuit Performance for Electricity Energy Saving of Emergency Lamps

Eka Nuryanto Budisusila[1], **Bustanul Arifin**[2]

[1, 2] Electrical Engineering Department of Industrial Engineering Faculty of Sultan Agung Islamic University (UNISSULA)

[1] ekanbs@unissula.ac.id, [2] bustanul@unissula.ac.id

Abstract. The alternative energy such as battery as power source is required as energy source failures. The other need is outdoor lighting. The electrical power source is expected to be a power saving, optimum and has long life operating. The Joule-Thief circuit is one of solution method for energy saving by using raised electromagnetic force on cored coil when there is back-current. This circuit has a transistor operated as a switch to cut voltage and current flowing along the coils. The present of current causing magnetic induction and generates energy. Experimental prototype was designed by using battery 1.5V to activate Light Emitting Diode or LED as load. The LED was connected in parallel or serial circuit configuration. The result show that the joule-thief circuit able to supply LED circuits up to 40 LEDs.

1. Background

Along with the improvement of technology, electrical devices that initially require great energy in operation gradually began to be replaced with electricity-saving devices, and other devices that is more environmentally friendly. The effort to save electricity is likely to be continued to develop. The availability of electrical energy given is unbalanced with the needs and demands of tremendous power supplies [1][2][3]. From problems above, an idea to save electrical energy in a way to use it optimally was occurred. One of solution is by exploiting the potential of basic electric energy generation through the development of electrical components that generate electromagnetic fields in the form of windings or coils. The basic working principle of the proposed circuit is by applying electromotive force (EMF) or electro mechanics force (EMF) in optimal way through the concept of magnetic induction. One of application of the concept above is a circuit called as joule-thief. This circuit is also known as simple blocking transistor circuit that is working as a thief of energy that can generate electrical energy when the energy sources are very small [4]. A joule-thief circuit prototype is proposed testing by considering many practical terms without any in-depth analysis in the laboratory to know the performance of the circuit [5][6].

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2. System Design

In this research, system is designed as the basic of Joule-thief circuit including power supply, solenoid in toroidal form, transistor and output loads.

Each block or subsystem in the system is varied according to the characteristics of each component. The source is variable voltage input. The transistor circuit is constructed from different types of resistance and the current base settings. Solenoid in toroidal form is made in various amounts of primary and secondary windings. The load is Light Emitting Diode (LED) in series and parallel configuration as variable load [3][4][5].

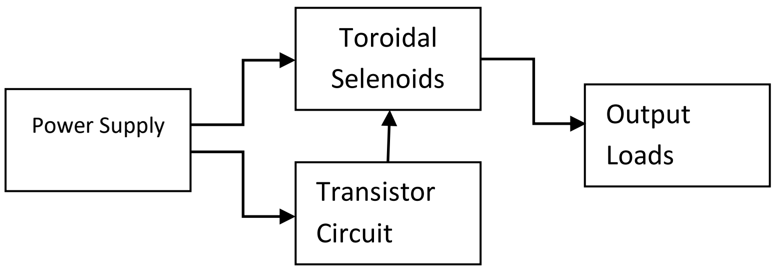

Figure 1. System Design Block

3. Research Method

As the block on the system, circuit and components are already constructed, then measurement is carried out by measuring voltage and current using multimeter. Waveform of signals and electromagnetic waves are observed by using an oscilloscope. The intensity LED lights is measured by the digital luxmeter.

4. Data And Analysis

Joule-thief circuit testing is made from several part of components in circuits. Many variation in the prototype is applied by changing the number of windings and the type of transistor. In Figure 2, a DC power supply is 1.5 volt b. Oscilloscope GW-Instek GOS-6200 is used to display observed signals. The oscilloscope can measure the frequency up to 200 MHz. Measurement of the output signal is done in two ways i.e. first measurement is the pulse output with no load and a second measurement is pulse output with LED loads

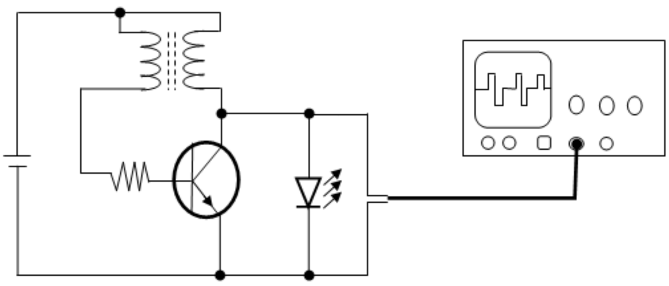

Figure 2. Joule-thief circuit test

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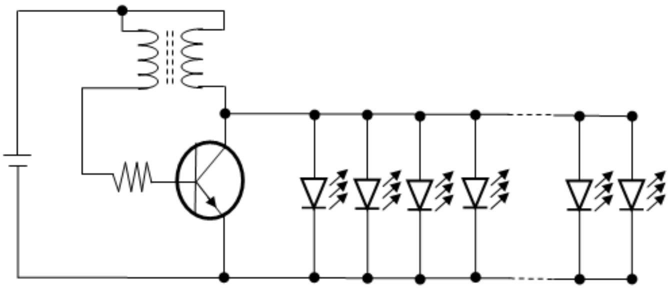


Figure 3. Parallel LEDs Load Circuit

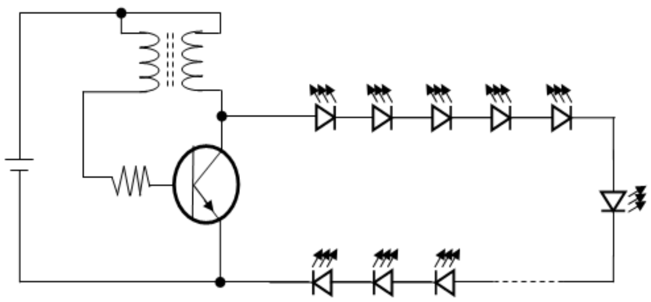


Figure 4. Serial LEDs Load Circuit

Testing is conducted by creating multiple variations of component such as the changes in the number of windings on ferrite toroid by keeping diameter remains the same. Circuit-1 use the equal coil between the primary and secondary windings. The primary winding are 22 turns and the secondary windings are 22 turns. Circuit-2 use ratio winding of primary and secondary coil in 30: 50. Winding ratio for the circuit-3 is 15: 100 and 20: 40 for circuit-4.

Measurement Analysis :

At no load condition the measurements results for circuit shows that the peak to peak voltage (Vpp) is 60 V, with a 353.75 kHz frequency at 20 V/div. On load condition as the LED is plug in, voltage recorded is 6 V, by adjusting LED load then the an average voltage is 3 volts. On the second circuit, no-load measurement Vpp measured up to 140 V (7 x 20V), with a frequency of 50 kHz. On load condition, the measurement of voltage is in about 6 volts. For circuit-3, the measurement results show the voltage 70 V with 70.15 kHz. On load condition the voltage drops up to 4 volts. At no-load measurements for circuit-4, the produced voltage is30 volts with of 331.04 kHz frequency and on load condition the voltage is 3.5 voltages.

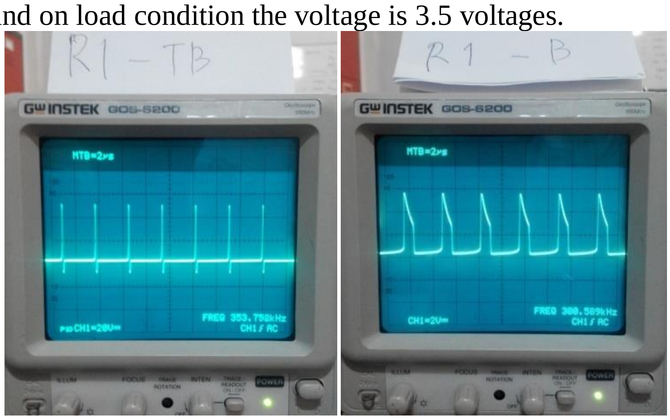


Figure 5. Measurement Result of Circuit 1 without and within load

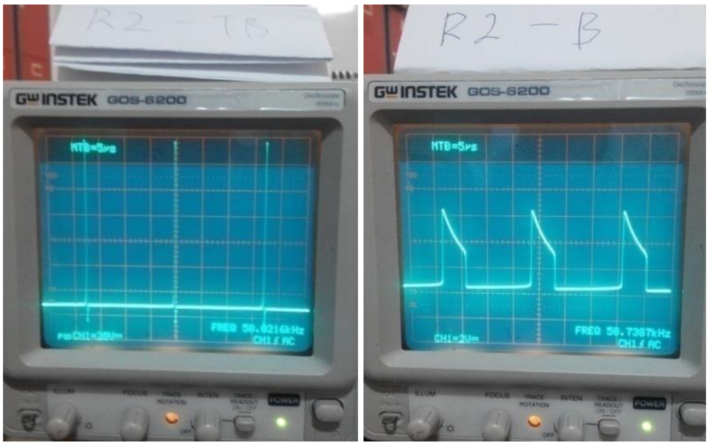


Figure 6. Measurement Result of Circuit 2 without and within load

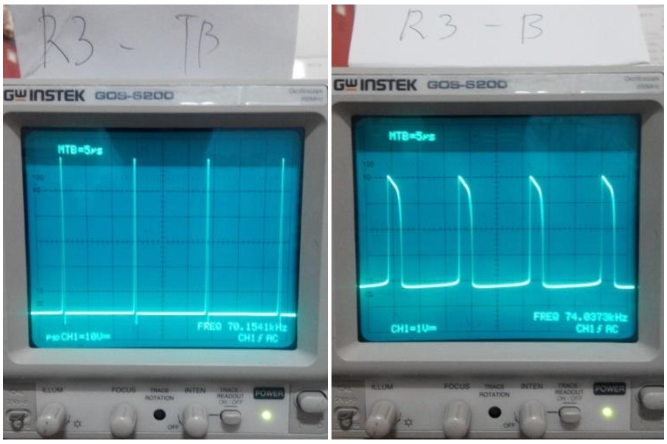


Figure 7. Measurement Result of Circuit 3 without and within load

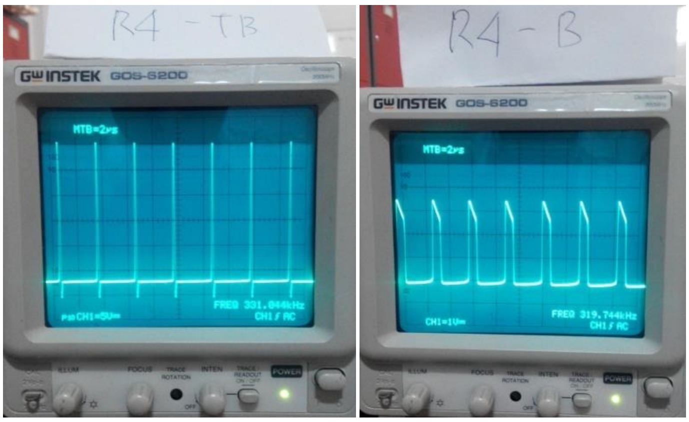
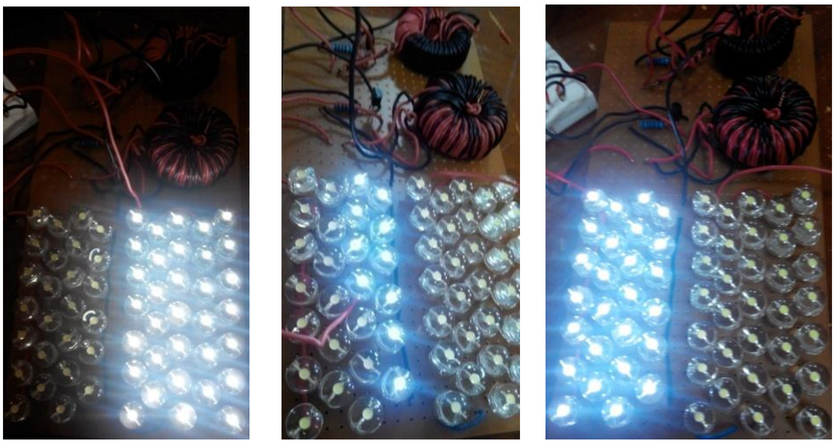


Figure 8. Measurement Result of Circuit 4 without and within load

The test condition is continued by arranging all LED in series or parallel. There are 33 LEDs installed in the circuit. Circuit-1 provides the dimmest lighting, while the other circuit tends to light brighter.

When 26 LEDs are installed in series circuit, all LED circuits can light all over, except for circuit 1. The circuit-1 is only capable to ignite 10 LEDs.



(a) (b) (c)

Figure 9. (a) All Circuit LED Flame in Parallel Load
(b) Maximum LED Flame in serial Load on Circuit 1
(c) LED Flame in serial Load on Circuit 2, 3 and 4

Based on experimental results, number of coils wound around a ferrite toroidal determines the magnitude voltage and current generated on the output side. More turns gives more voltage and current at out put side in consequently more LED can be ignited. At series circuit, higher voltage with constant current is indicated by the number of LEDs which are ignited with constant light intensity. In parallel configuration, the large amount of current produced by joule thief circuit is indicated by the number of LED with bright light or high light intensity.

The comparison of the number of primary and secondary windings also affect the performance of the joule thief circuit. The more windings on the primary side than the secondary side provide strong currents in the output circuit. Instead, a more number of windings in the secondary will generate higher voltage at the output side.

Although the joule thief circuit generates a high voltage, this proposed circuit does not make the LED lights as the load to be damaged or burnt out due to excessive voltage because the given load automatically adjust the voltage corresponding to average obtained voltage. In addition, the output voltage in the form of pulses with a certain frequency gives the average voltage rise time (ON) and the down time (OFF) and it is multiplied to the peak voltage (Vpp).

5. Conclusion and Sugestion

5.1. Conclusion

1. The Joule thief circuit can provide reinforcement of current and voltage from 1.5 V DC battery source to supply the load LEDs by utilizing the reverse flow current that occurs at the time of toroidal winding current source or voltage through cut-breaking conducted by the NPN transistor.
2. More coils wound on toroidal ferrite give the higher voltage and current.
3. Voltage performance test is successfully conducted by using series LED circuit and current performance test is effectively conducted by using parallel LED circuit.

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4. The output voltage of joule thief circuit can be adjusted to the LED load and it does not cause damage to the LEDs.

5.2. Suggestion

1. To improve the performance of the Joule-Thief circuit for larger power requirements, the use of a ferrite toroid with a larger diameter or more winding can be proposed together with the use of a switching transistor with the larger currents type such as 2N3055.
2. Further testing to determine the ability of joule-thief circuit in energy savings and battery life for supplying circuit and load is interesting because the exhausted battery or battery with voltage less than 1 volt still able to ignite the LED load as transistor switching is kept to switch.

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